

FERC Technical Conference
Increasing RT and DA Market Efficiency through Improved Software

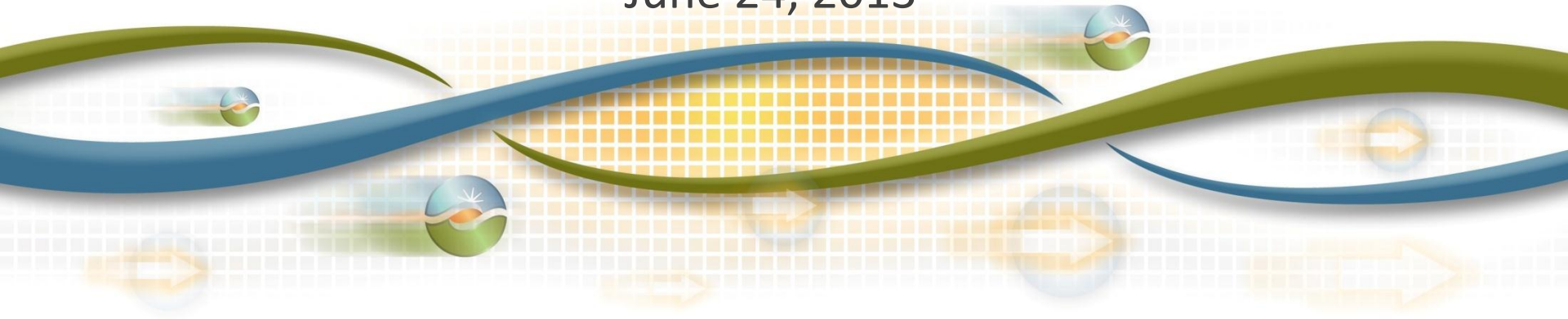
Hybrid Approach for Incorporating Uncertainty in CAISO's Market Operations

Khaled Abdul-Rahman - Executive Director, PSTD & SG

Hani Alarian – Director, PSTO

Clyde Loutan – Sr. Advisor, REI

June 24, 2013



Agenda

- Operational Impacts of Uncertainty Levels on Managing the Transmission Grid
- Flexible Ramp Capacity to Meet Operational Uncertainty
- Flexible Ramp Capacity Tool and Its Stochastic input datasets
- Flexible Ramp Capacity Constraints in Market Optimization
- Integrated Market/VSA/DSA on-line and Look-Ahead Modes
- Conclusion

Optimizing Market Operation

- The objectives of the market optimization is to balance net expected demand with net expected supply at least cost production cost respecting system reliability constraints.
- The optimized unit commitment and dispatch levels may be sufficient to satisfy the expected system condition.
- To the extent imbalance conditions vary from the expected condition, sufficient flexibility must be committed to respond to such variations.

Increased Uncertainty Levels

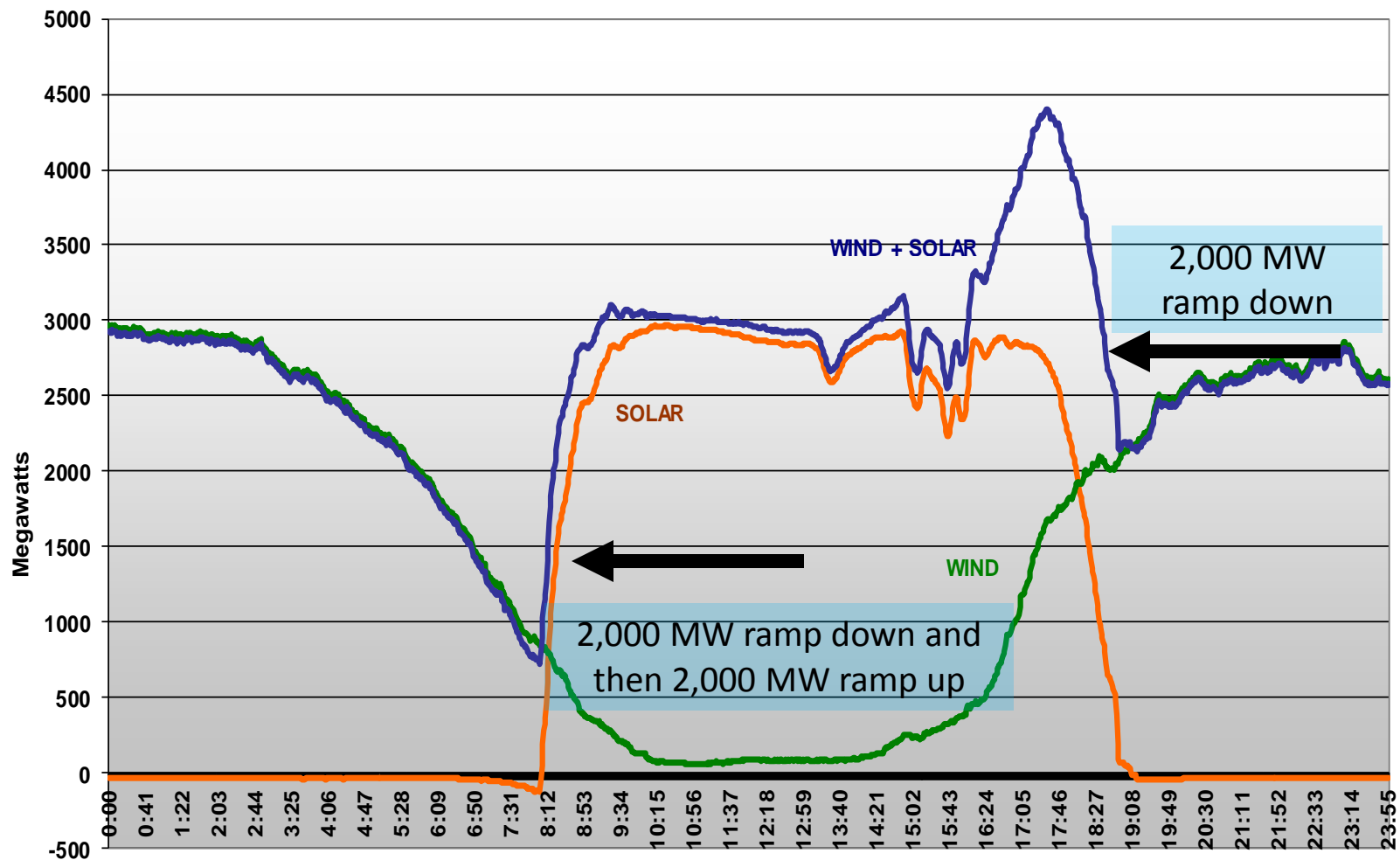
- **Increased supply volatility** - Approximately 20,000 MW of wind and solar capacity is needed to meet 33% RPS
- **Uncertainty surrounding thermal resources** - Approximately 12,000 MW of thermal generation will be repowered or retired
- **Less predictable load patterns** – Changes in load patterns due to DER and PEV
- **Changing revenue patterns** - Decreasing marginal prices and changes in resource operational pattern

DER – Distributed Energy Resources
PEV – Plug in Electric Vehicle

Operational Impacts of Uncertainty

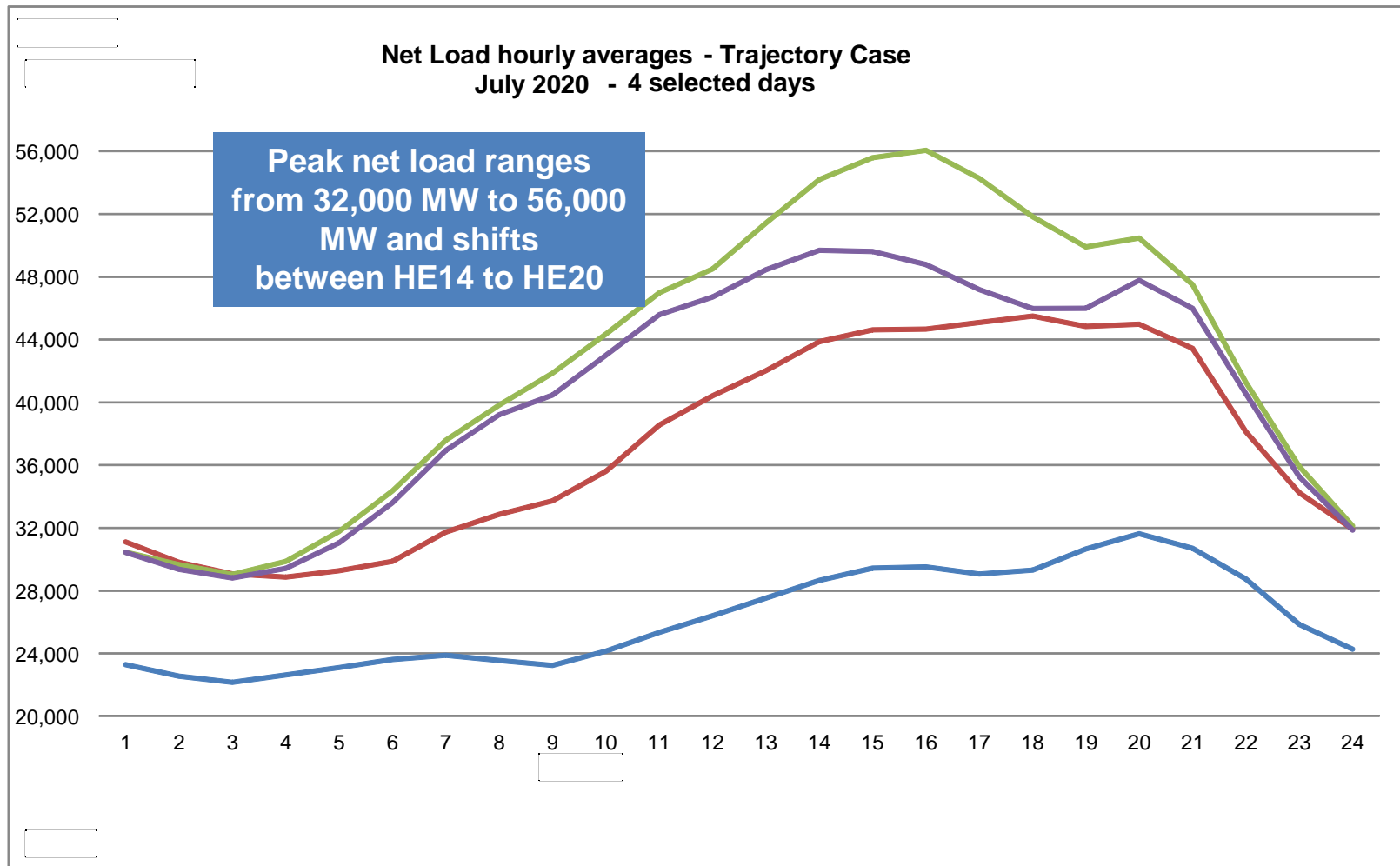
- Increased number of operational **ramps across various time-frames**
- Increased **intra-hour load-following up/down** requirements
- Increased requirements for **regulation up and down**
- Increased **flexibility** needs
- Increased frequency of **over-generation** conditions
- Concerns of arresting **frequency** after a disturbance
- Impact of **demand response and other DER resources** on the transmission grid operation
- Inadequate **real-time awareness and analysis tools** to assess the system security and stability

Ramp Challenges

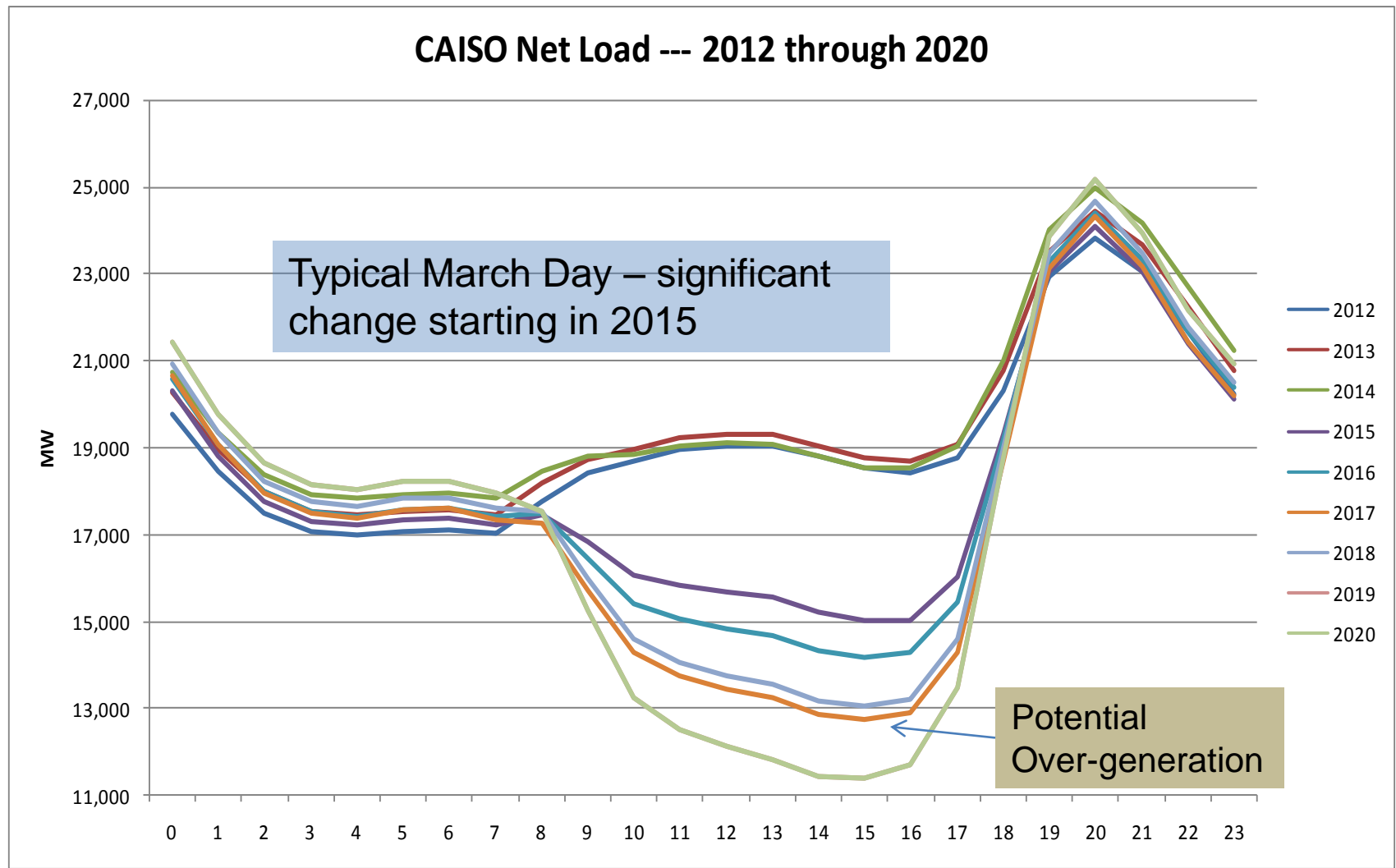


Data based on summer production profiles

Large range of net load in summer period requires flexible capacity commitment capability



Net load pattern changes significantly starting in 2015



Forecasting Process for Greener Fleet

- Weather-dependent power forecasting should include various weather data such as temperature, wind speed, wind direction, sunshine minute, cloud coverage, humidity, pressure gradient, season, date, time
- Renewable resources energy production forecasting
- Improved Load forecasting with a significant participation of “non-visible” distributed resources
- “Load Following” requirements forecasting
- Ramp requirements forecasting
- Reserves forecasting (Regulation, Spin, Non-Spin)

Sources of Imbalance Energy

- Changes in forecasted load conditions or forecast errors
- Variable energy resources supply delivering more or less than their forecasts
- Differences in market interval granularity between hierarchy markets
- Differences between actual and modeled startup and shut down resource MW profiles for the different resources, and even for the same resource under various operations conditions
- Differences between actual and modeled combined cycle transition profile from one configuration to another
- Forced outages or contingency events
- Derates of transmission constraints or resource operating capabilities
- High hydro run-off decreasing resource flexibility
- Unplanned curtail of imports or reduction in accepted e-tags for inter-ties
- Resources not following instructions, i.e. uninstructed deviations

Flexible Ramp Modeling Challenge

- **Stochastic Optimization:**
 - Complex probabilistic or stochastic optimization techniques
 - More appropriate for offline planning applications rather than operational type applications due to market timeline considerations
 - Provide operators with information regarding the likelihood of a solution occurring within some short time frame
- **Multi-Run Deterministic Optimization:**
 - May solve three times, one equal to the forecasted value of load; a second one using higher value and a third one using lower value than the forecasted load
- **CAISO's Single Run Deterministic Optimization:**
 - Solve one deterministic optimization with flexi-ramp constraints

Flexible Ramp Capacity Tool

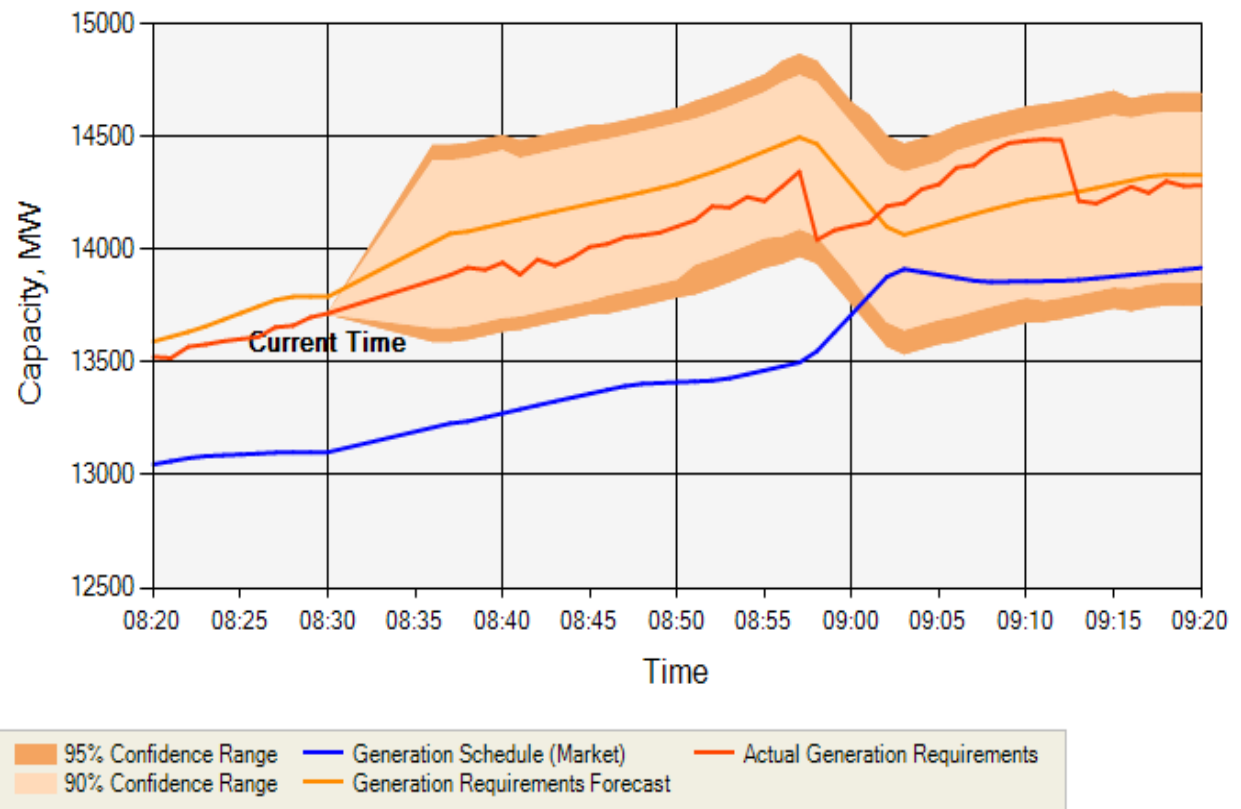
- Different operational uncertainty levels are captured as stochastic input datasets including:
 - ✓ most up-to-date load, wind & solar forecast,
 - ✓ Real-time operating data,
 - ✓ Resources committed through various market runs
 - ✓ Generator **forced outage** information,
 - ✓ Interchange schedules
 - ✓ **Stochastic** relationships between the input datasets
 - ✓ Updated every 5 minutes
- Requirements are defined based on agreed upon confidence levels

Flexible ramp capacity requirements are predicted up to 24 hours ahead of time

Input Data

- Most up-to-date load, wind & solar forecast,
- Real-time operating data,
- Resources committed through various market runs,
- Generator forced outage information,
- Interchange schedules
- Stochastic relationships between the input datasets
- Updated every 5 minutes

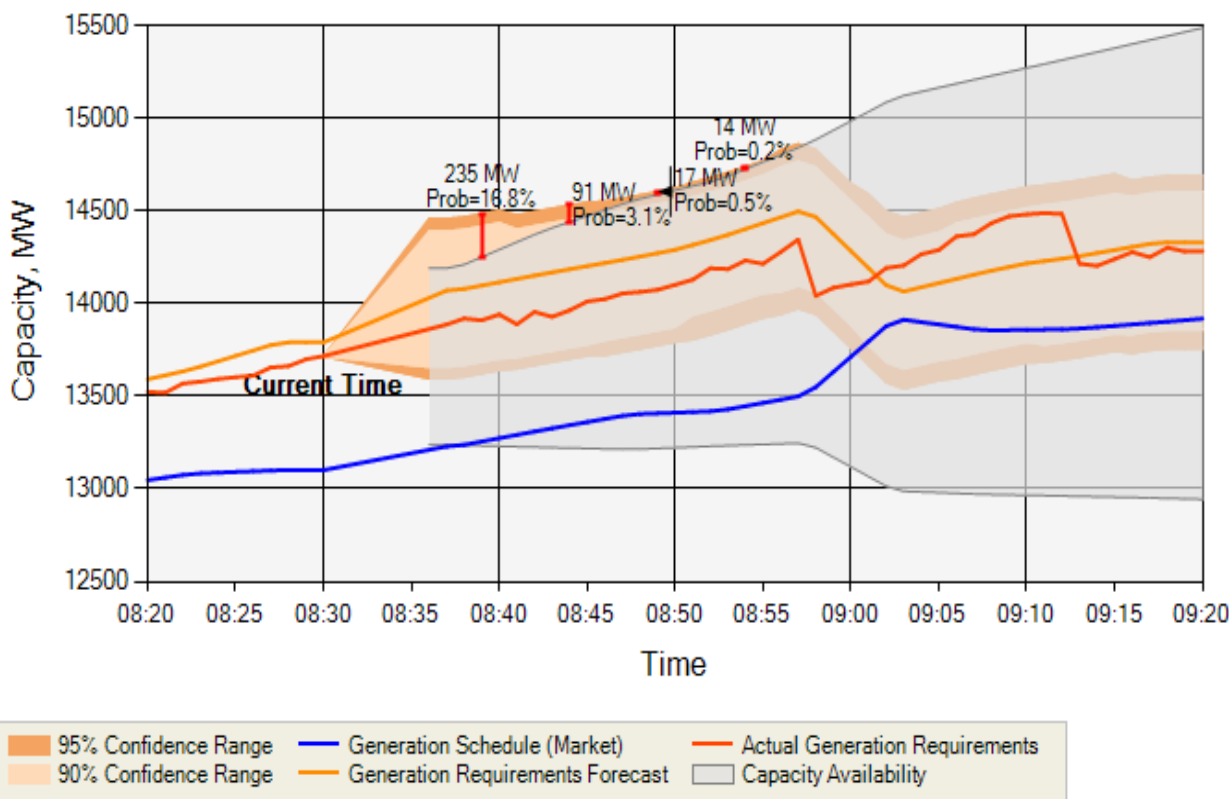
Expected Real-Time Load Following Capacity Requirements and Availability (6/5/2011 8:30:00 AM)



Flexible ramp capacity requirements are predicted up to 24 hours ahead of time

- The shaded area displays the upward and downward generating capacity available for dispatch from conventional resources
- At 8:55 there was a 210 MW shortfall and price spiked to \$1,000
- Predicted 90% of upward price spikes in June
- Predicted 98% of the negative spikes

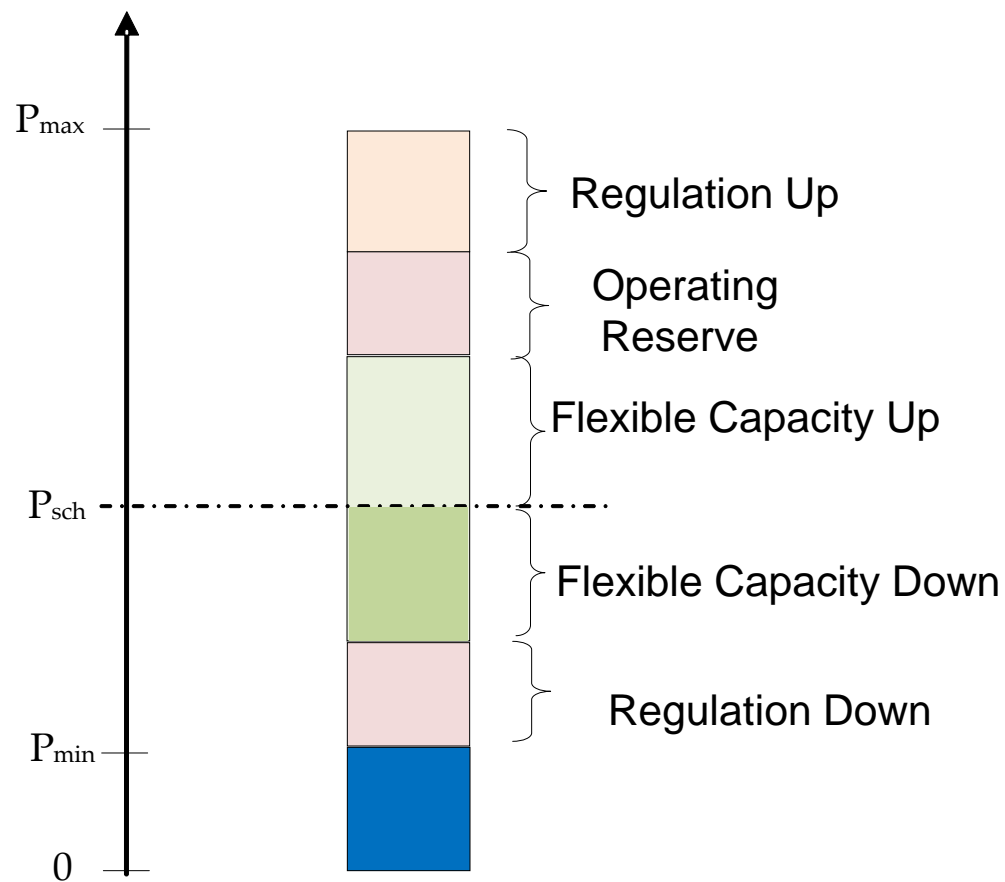
Expected Real-Time Load Following Capacity Requirements and Availability (6/5/2011 8:30:00 AM)



Flexible Ramp Capacity Constraints in CAISO Market Optimization

- Shortage of ramping capability may result in:
 - Leaning on the interconnection
 - RTD energy price is not priced by economic bids, but by administrative penalty prices, which may impact market efficiency in the long run
- CAISO enhanced its market optimization by modeling flexible capacity ramping constraints to ensure availability of ramp feasible on-line capacity

A single resource can provide multiple services



Observed Benefits of Flexible Ramp Capacity Constraints

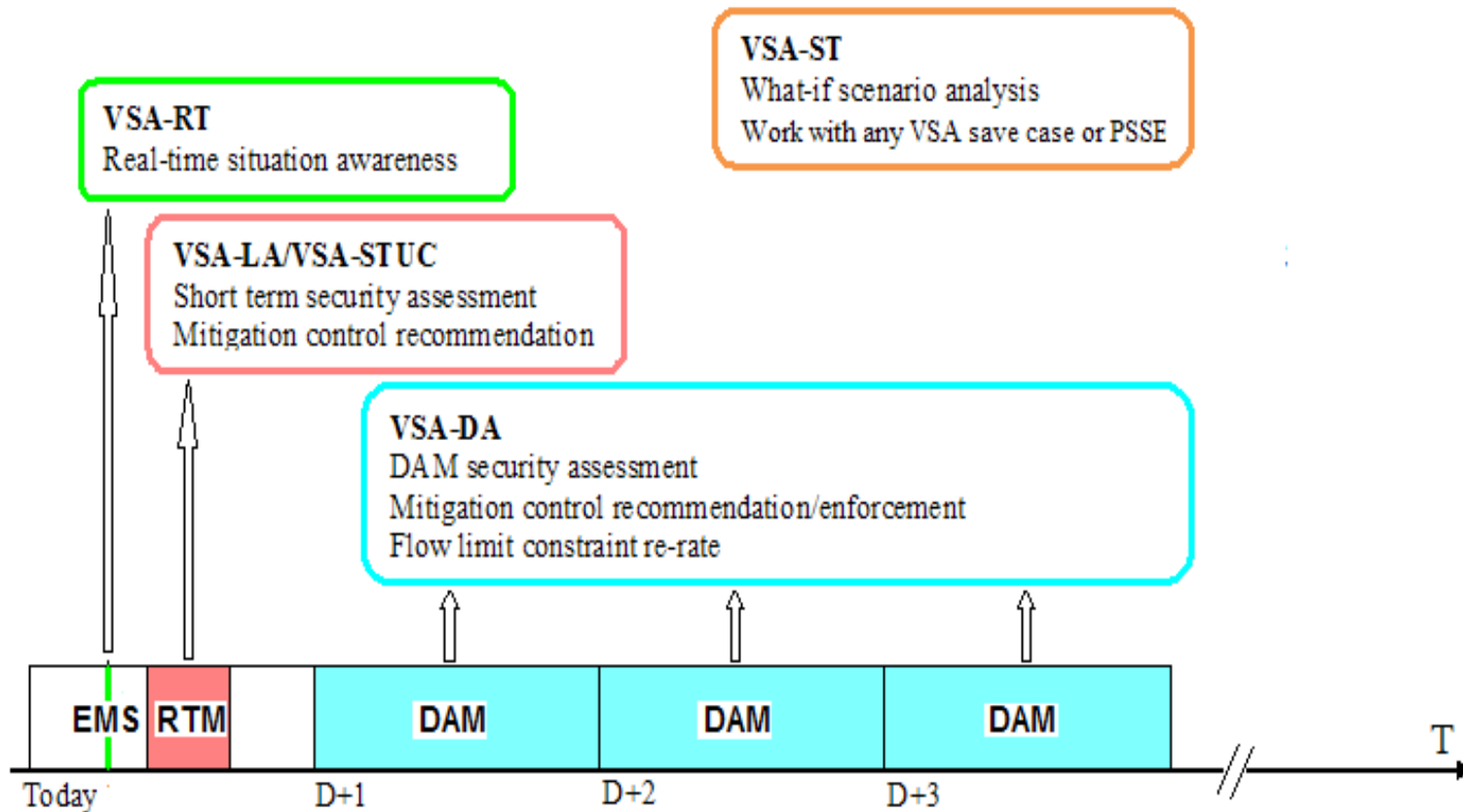
- **Increased reliability:** reduction in number of intervals with imbalance energy shortage
- **Reduction in price volatility:** Reduction in the number of intermittent price spikes
- **Enhanced market efficiency:** reduction in number of manual exceptional dispatched or out of market dispatch.
- The net average **daily market saving** of upward flexible ramp constraint is about 5.4%*

* based on average daily operation cost for a one week period before activation and one week after activation

Integrated Market/Voltage Stability Assessment /Dynamic Stability Assessment at CAISO

- Uncertainty around:
 - Is the system secure after a disturbance?
 - Will the system be secure in the scheduled operating condition to withstand a disturbance?
 - How much additional demands the system can support in current or future operating condition?
 - How much power can be safely transferred through a transmission pathway in current or future operating condition?

Integrated Market /VSA/DSA Solution



Pertinent Results of VSA

- System Load Margin
- Interface Flow Limit, Flow Margin, and Safety Margin
- Limiting Contingency
- Weakest Location
- Type of Voltage Instability
- Preventive/Enhancement Control Recommendations
- Impact of variable energy resources on stability margin
- The outputs of the stochastic on-line VSA are also be presented as probability bands.
- These probability bands will comprise of a region of high probability (showing upper and lower bounds) and a region of low probability in similar fashion.

Conclusion

- Ongoing improvement in weather-dependent power forecasting is a key to reduce operational uncertainty.
- hybrid approach is implemented at CAISO using both Stochastic and deterministic approaches to resolve market optimization.
- System flexibility must be matched to the system-level needs that are created not just by variable resources but also by the entire fleet of supply and demand.
- Flexibility must be valued as an important resource characteristic.
- Forward procurement of flexible capacity ensures enough flexible resources are offered into the market.
- Integrated VSA/TSA on-line and look-ahead modes enhances system reliability and quality of market results

Q & A

For more follow up questions, please contact:

Dr. Khaled Abdul-Rahman

kabdul@caiso.com

Thank You